**Table 4.1.1.** Select Provincial Water Quality Monitoring Network (PWQMN) parameters from Mill Creek.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Parameter** | **Formula** | **Unit** | **Year range** | **Analysis method** | **# samples** |
| Ammonium | NH4+ | mg/L | 2007-2020 | total unfiltered reactive | 103 |
| Chloride | Cl- | mg/L | 2007-2022 | unfiltered reactive | 123 |
| Nitrate | NO3- | mg/L | 2007-2022 | total unfiltered reactive | 116 |
| Nitrite | NO2- | mg/L | 2007-2020 | unfiltered reactive | 103 |
| Phosphate | PO43- | mg/L | 2007-2020 | filtered reactive | 102 |
| Dissolved oxygen | - | mg/L | 2007-2020 | field | 105 |
| Conductivity | - | µS/cm | 2007-2022 | ambient | 124 |
| pH | - | - | 2007-2022 | field | 116 |

**Table 6.2.1.1.** Five months with the most extreme hot air temperatures at the Shade’s Mills Climate Station.

|  |  |  |
| --- | --- | --- |
| **Year** | **Month** | **Average air temperature (°C)** |
| 2020 | July | 24.3 |
| 2012 | July | 24.0 |
| 2011 | July | 24.2 |
| 2005 | July | 23.4 |
| 2002 | July | 24.0 |

**Table 6.2.1.2.** Five months with the most extreme cold air temperatures at the Shade’s Mills Climate Station.

|  |  |  |
| --- | --- | --- |
| **Year** | **Month** | **Average air temperature (°C)** |
| 2015 | February | -12.9 |
| 2014 | February | -9.17 |
| 2014 | January | -9.00 |
| 2009 | January | -8.97 |
| 2005 | October | -20.3 |

**Table 6.3.1.1.** Five years with the highest total precipitation values at the Shade’s Mills Dam Climate Station.

|  |  |
| --- | --- |
| **Year** | **Total yearly precipitation (mm)** |
| 2016 | 1889 |
| 2006 | 1113 |
| 2008 | 985 |
| 2019 | 966 |
| 2023 | 963 |

**Table 6.3.1.2.** Five years with the lowest total precipitation values at the Shade’s Mills Dam Climate Station.

|  |  |
| --- | --- |
| **Year** | **Total yearly precipitation (mm)** |
| 2015 | 464 |
| 2007 | 496 |
| 2017 | 607 |
| 2022 | 623 |
| 2011 | 629 |

**Table 9.1.1.** Five months with the highest average water temperatures at the Side Road 10 station.

|  |  |  |
| --- | --- | --- |
| **Year** | **Month** | **Average water temperature (°C)** |
| 2023 | July | 19.0 |
| 2012 | July | 19.4 |
| 2002 | July | 18.8 |
| 2001 | August | 19.0 |
| 2001 | July | 19.0 |

**Table 9.1.2.** Five months with the highest average water temperatures at the Aberfoyle station.

|  |  |  |
| --- | --- | --- |
| **Year** | **Month** | **Average water temperature (°C)** |
| 2019 | July | 20.9 |
| 2016 | August | 20.7 |
| 2011 | July | 21.1 |
| 2006 | July | 21.0 |
| 2005 | July | 21.2 |

**Table 9.1.3.** Five months with the lowest average water temperatures at the Side Road 10 station.

|  |  |  |
| --- | --- | --- |
| **Year** | **Month** | **Average water temperature (°C)** |
| 2019 | March | 0.173 |
| 2019 | February | 0.096 |
| 2018 | February | 0.282 |
| 2018 | January | 0.357 |
| 2003 | February | 0.561 |

**Table 9.1.4.** Five months with the lowest average water temperatures at the Aberfoyle station.

|  |  |  |
| --- | --- | --- |
| **Year** | **Month** | **Average water temperature (°C)** |
| 2019 | February | 0.673 |
| 2014 | January | 0.600 |
| 2009 | February | 0.753 |
| 2008 | February | 0.805 |
| 2005 | January | 0.730 |

**Table 9.1.5.** MK test results on water temperature during July and August.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Gauge** | **Metric** | **Year range** | **statistic** | **Sen’s slope** | **p-value** |
| Aberfoyle | Minimum | 1983-1991, 1994, 2003-2014, 2016-2019, 2022-2023 | -0.2346742 | -0.06398778 | 0.08524 |
| Aberfoyle | Maximum | 1983-1991, 1994, 2003-2014, 2016-2019, 2022-2023 | -0.03462127 | -0.008191975 | 0.8124 |
| Side Road 10 | Minimum | 1983-1991, 1994, 1999-2013, 2017-2018, 2022-2023 | 3.970333e-02 | 0.01010101 | 0.7782 |
| Side Road 10 | Maximum | 1983-1991, 1994, 1999-2013, 2017-2018, 2022-2023 | -0.245972 | -0.08153409 | 0.06562 |

**Table 11.2.1.** Breakdown of the biodiversity inventory entries by taxonomic group. Class-level divisions are not known for the Phyla Alphaproteobacteria, Brachipoda, and Gastrotricha, and the Kingdom Plantae.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Domain** | **Kingdom** | **Phylum** | **Clas** | **# Entries** |
| Eukaryota | Animalia | Chordata | Actinopterygii | 33 |
| Bacteria | Proteobacteria | Alphaproteobacteria | - | 1 |
| Eukaryota | Animalia | Chordata | Amphibia | 17 |
| Eukaryota | Animalia | Arthropoda | Arachnida | 20 |
| Eukaryota | Animalia | Chordata | Aves | 148 |
| Eukaryota | Animalia | Rotifera | Bdelloidea | 1 |
| Eukaryota | Animalia | Mollusca | Bivalvia | 5 |
| Eukaryota | Animalia | Brachiopoda | - | 1 |
| Eukaryota | Animalia | Nematoda | Chromadorea | 1 |
| Eukaryota | Animalia | Annelida | Clitellata | 35 |
| Eukaryota | Animalia | Arthropoda | Collembola | 2 |
| Eukaryota | Animalia | Porifera | Demospongiae | 2 |
| Eukaryota | Animalia | Arthropoda | Diplopoda | 3 |
| Eukaryota | Animalia | Tardigrada | Eutardigrada | 2 |
| Eukaryota | Fungi | - | - | 24 |
| Eukaryota | Animalia | Mollusca | Gastropoda | 12 |
| Eukaryota | Animalia | Gastrotricha | - | 4 |
| Eukaryota | Animalia | Arthropoda | Hexanauplia | 2 |
| Eukaryota | Animalia | Nemertea | Hoplonemertea | 1 |
| Eukaryota | Animalia | Cnidaria | Hydrozoa | 2 |
| Eukaryota | Animalia | Arthropoda | Insecta | 441 |
| Eukaryota | Fungi | Ascomycota | Lecanoromycetes | 1 |
| Eukaryota | Animalia | Arthropoda | Malacostraca | 12 |
| Eukaryota | Animalia | Chordata | Mammalia | 16 |
| Eukaryota | Animalia | Rotifera | Monogonota | 2 |
| Eukaryota | Animalia | Arthropoda | Ostracoda | 4 |
| Eukaryota | Animalia | Bryozoa | Phylactolaemata | 1 |
| Eukaryota | Plantae | - | - | 381 |
| Eukaryota | Animalia | Chordata | Reptilia | 12 |

**Table 11.3.2.1.** Species at Risk within Ontario, found in the Mill Creek Subwatershed and documented in the biodiversity inventory. Includes legal at-risk status; an asterisk (\*) indicates that the species is under consideration for status change.

|  |  |  |  |
| --- | --- | --- | --- |
| **Taxonomic Group** | **Common Name** | **Scientific Name** | **Status** |
| Amphibian | Jefferson salamander | *Ambystoma jeffersonianum* | Endangered |
| Amphibian | Western chorus frog | *Pseudacris triseriata* | Threatened |
| Insect | Monarch butterfly | *Danaus plexippus* | Endangered |
| Bird | Eastern whip-poor-will | *Antrostomus vociferus* | Threatened\* |
| Bird | Common nighthawk | *Chordeiles minor* | Special Concern |
| Bird | Eastern wood-pewee | *Contopus virens* | Special Concern |
| Bird | Bobolink | *Dolichonyx oryzivorus* | Threatened\* |
| Bird | Rusty blackbird | *Euphagus carolinus* | Special Concern |
| Bird | Barn swallow | *Hirundo rustica* | Threatened\* |
| Bird | Wood thrush | *Hylocichla mustelina* | Threatened |
| Bird | Bank swallow | *Riparia riparia* | Threatened |
| Bird | Least bittern | *Ixobrychus exilis* | Threatened |
| Bird | Bobwhite quail | *Colinus virginianus* | Endangered |
| Bird | Red-headed woodpecker | *Melanerpes erythrocephalus* | Endangered |
| Bird | Canada warbler | *Cardellina canadensis* | Threatened\* |
| Bird | Henslow’s sparrow | *Ammodramus henslowii* | Endangered |
| Reptile | Blanding’s turtle | *Emydoidea blandingii* | Endangered |
| Reptile | Snapping turtle | *Chelydra serpentina* | Special Concern |
| Reptile | Midland painted turtle | *Chrysemys picta marginata* | Special Concern |
| Reptile | Northern map turtle | G*raptemys geographica* | Special Concern |
| Reptile | Eastern milksnake | *Lampropeltis triangulum* | Special Concern |
| Plant | Dense blazing star | *Liatris spicata* | Threatened |

**Table 11.3.3.1.** EPT genera in the Mill Creek biodiversity inventory

|  |  |
| --- | --- |
| **Order** | **Examples** |
| Ephemeroptera (Mayflies) | *Leptophlebia spp.*  *Maccaffertium spp.*  *Paraleptophlebia spp.* |
| Plecoptera (Stoneflies) | *Amphinemura spp.*  *Allocapnia spp.* |
| Trichoptera (Caddisflies) | *Hydropsyche spp.*  *Hydroptila spp.*  *Oecetis spp.* |

**Table 11.4.1.** Taxonomic group, common name, and scientific name of some common invasive species confirmed in Mill Creek.

|  |  |  |
| --- | --- | --- |
| **Taxonomic Group** | **Common Name** | **Scientific Name** |
| Aves | European starling | *Sturnus vulgaris* |
| Fish | Brown trout | *Salmo trutta* |
| Insecta | Japanese beetle | *Popillia japonnica* |
| Plantae | Boxelder maple | *Acer negundo* |
| Plantae | Norway maple | *Acer platanoides* |
| Plantae | Garlic mustard | *Alliaria petiolata* |
| Plantae | American bittersweet | *Celastrus scandens* |
| Plantae | Bull thistle | *Cirsium vulgare* |
| Plantae | Autumn olive | *Elaeagnus umbellata* |
| Plantae | Glossy buckthorn | *Frangula alnus* |
| Plantae | Dame's rocket | *Hesperis matronalis* |
| Plantae | Yellow iris | *Iris pseudacorus* |
| Plantae | Tatarian honeysuckle | *Lonicera tatarica* |
| Plantae | Purple loosestrife | *Lythrum salicaria* |
| Plantae | Common reed grass | *Phragmites australis* |
| Plantae | European buckthorn | *Rhamnus cathartica* |
| Plantae | Siberian elm | *Ulmus pumila* |
| Plantae | European swallowort | *Vincetoxicum rossicum* |

**Table 11.4.2.** Taxonomic group, common name, and scientific name of aquatic invasive species confirmed to be in water systems near Mill Creek.

|  |  |  |
| --- | --- | --- |
| **Taxonomic Group** | **Common Name** | **Scientific Name** |
| Crustacea | Rusty crayfish | *Faxonius rusticus* |
| Fish | Round goby | *Neogobius melanostomus* |
| Fish | Sea lamprey | *Petromyzon marinus* |
| Mollusca | Zebra mussels | *Dreissena polymorpha* |

**Table 11.4.3.** Common name, pathogen, and affected taxonomic group of invasive pathogens confirmed to be in the area around Mill Creek.

|  |  |  |
| --- | --- | --- |
| **Common Name** | **Pathogen** | **Affected Taxonomic Group** |
| Viral hemorrhagic septicemia (VHS) | Viral hemorrhagic septicemia virus | Fish |
| Snake fungal disease (SFD) | *Ophidiomycosis* | Snakes |
| Ranavirus | *Ranavirus spp.* | Reptiles, Amphibians |
| Chytridiomycosis | *Batrachochytrium dendrobatidis* and *Batrachochytriumsalamandrivorans* | Amphibians |
| Dutch elm disease (DED) | *Ascomycota* | Plants |
| White pine blister rust | *Cronartium ribicola* | Plants |

**Table 11.5.1** Taxonomic group, common name, scientific name, and habitat components of some endangered species that may be suitable for reintroduction in Mill Creek. All information is taken from the Government of Canada’s Species at Risk Public Registry (n.d.).

|  |  |  |  |
| --- | --- | --- | --- |
| **Taxonomic Group** | **Common Name** | **Scientific Name** | **Habitat Components** |
| Aves | Barn owl | *Tyto alba* | Old agricultural fields, rough pasture, hayfields, grassy roadsides and marshes for foraging |
| Aves | Red-headed woodpecker | *Melanerpes erythrocephalus* | Variety of treed habitats (deciduous woodlands, open woodlots, parks, agricultural and urban areas, wetlands, etc.) |
| Fish | Redside dace | *Clinostomus elongatus* | Pools and slow-moving areas of small streams with overhanging trees to offer cover; bed of rocks, gravel, or sand |
| Insecta | Gypsy Cuckoo Bumble Bee | *Bombus bohemicus* | Open meadows, mixed farmlands, urban areas |
| Insecta | Monarch | *Danaus plexippus* | Milkweed (larval food source) |
| Insecta | Nine-spotted lady beetle | *Coccinella novemnotata* | Habitat generalist |
| Insecta | Rusty-patch bumble bee | *Bombus affinis* | Wide range of habitats |
| Plantae | Butternut | *Juglans cinerea* | soils of pH 5.5 to 8; occurs in a wide range of habitats; seedling establishment, growth, and survival to maturity are most frequent in stand openings, riparian zones and forest edges |

**Table 14.1.1.** Restoration goals and objectives from the 1996 Mill Creek Subwatershed Study (GRCA, 1996, p. 7-7).

|  |  |
| --- | --- |
| **Goals** | **Objectives** |
| Restore, protect, and enhance water quality and associated aquatic resources and water supplies | * Maintain existing recharge and discharge characteristics * Control sediment discharge and provide erosion control during development * Maintain/reduce existing erosion rates following development * Maintain and enhance cold-water fisheries potential as sub-watershed creeks |
| Conserve, protect, and restore natural land, water, forest, and wildlife res | * Protect natural area functions/features from development * Enhance natural area features and functions in the long term |
| Protect, restore, and enhance ground-water quantity and quality | * Maintain infiltration, baseflow, and discharge to natural features * Ensure continued aggregate extraction does not impair existing groundwater quantity and quality |
| Minimize the threat to life and the destruction of property and natural resources from flooding and erosion, and preserve natural floodplain hydrologic function | * Minimize risk of life and property with future development * Control development in the floodplain |

**Table 14.1.2** Current **r**estoration goals and objectives building upon the restoration goals from the GRCA 1996 report.

|  |  |
| --- | --- |
| **Goals** | **Objectives** |
| Continuous monitoring and protection of watershed against threats to the biodiversity within the Mill Creek sub-watershed of the Grand River | * Monitor and limit land development surrounding the watershed (i.e., residential, road, and agricultural development) * Protect floodplain areas from future development |
| Protect and enhance groundwater upwellings, water quality, and water temperature | * Continuous monitoring of impacts from the continued aggregate extraction project on Mill Creek * Protection against development around groundwater upwellings * Continuous monitoring of water temperature in developed areas of Mill Creek * Continuous monitoring of water quality parameters (PWQMN parameters) with increased development and a changing climate |
| Protect and enhance structural features of Mill Creek | * Maintain areas prone to erosion * Continue to maintain habitat for wildlife (i.e., fish habitat) * Protect floodplain function from future development |
| Protect and enhance the ecological functions of the watershed | * Continuous monitoring of VEC, SAR, and bioindicator species * Continuous monitoring of macro-benthic communities * Conduct fish survey with consistent data collection methods * Maintain and enhance fisheries potential in a cold-water stream * Protect and conserve habitat heterogeneity surrounding the subwatershed (i.e., the diversity of vegetation types such as wetlands, lowland thickets, and mixed forests) |
| Emphasize the importance of monitoring the biodiversity of Mill Creek | * Biological monitoring using consistent data collection methods * Create publicly accessible biological monitoring data |
| Enhance public awareness of long-term monitoring efforts surrounding Mill Creek | * Create educational opportunities for local communities * Increase social media presence * Create publicly accessible and up-to-date information regarding restoration efforts * Evaluate public valuation of long-term monitoring and restoration projects |

**Table 14.3.1.** Restoration efforts of stakeholders in relation to Mill Creek

|  |  |  |
| --- | --- | --- |
| **Restoration stakeholders** | **Background** | **Contemporary restoration efforts** |
| * FoMC * Stewardship Ranger program | * The ranger program was implemented in 2003, initially supported by the Trillium Foundation Grant. Today members of the community, businesses and organizations donate money to the FoMC to ensure that the Ranger Stewardship Program continues each summer. * Ranger program took a break between 2020-2021 due to COVID-19. | * Mill Creek ranger reports years 2003 to 2019 * Mill Creek ranger reports 2022 to 2024 * Restoration efforts include manipulation and improving physical features of Mill Creek. Building or installation of **deflectors** and **sweepers**, obstruction removal, garbage removal, trail and parking maintenance, and creating suitable habitat for A = aquatic organisms, particularly trout. * Vegetation management, planting and invasive species management * Abiotic data collection * Biotic data collection, and electrofishing * Descriptions, locations and years where restoration efforts were conducted can be found in section 14.4 |
| * FoMC * GRCA * Hajibabaei Lab at the Center for Biodiversity Genomics (CBG) at the University of Guelph (UofG) | * STREAM: Sequencing The Rivers for Environmental Assessment and Monitoring), a collaboration between Living Lakes Canada (LLC) and Environmental and Climate Change Canada (ECCC), led by the Hajibabaei Lab at the CBG of UofG. * STREAM is a biomonitoring project that implements community-based monitoring and DNA metabarcoding to evaluate benthic communities in watersheds across Canada. * The report produced for FoCM and the GRCA, health assesses the health of the benthic community in Mill Creek. | * STREAM: Preliminary DNA Data, 2024 * Sampling in nine sampling locations in the Grand River watershed, five of which were done on Mill Creek. * Benthic DNA samples were collected following the STREAM field sampling protocol. * Full taxonomic list identified to genus and species is provided in an Excel spread sheet. |
| * Hadi Dhiyebi, Simon Courtenay and Mark Servos from the Department of Biology at the University of Waterloo | * Prepared for the Friends of Mill Creek * The 1996 report identifies multiple stressors and change in climate as future concerns for Mill Creek * The goal of this project was to explore the knowledge gaps and potential threats to the Mill Creek sub-watershed | * Cumulative Effects in the Mill Creek Sub-watershed, 2018 * Review and analyze existing biomonitoring data related to Mill Creek and evaluate the health and sustainability of the creek from a cumulative effect standpoint * To determine if sufficient sampling is being done on the creek * Offer recommendations for further management of the Mill Creek watershed * Recommendations include consistent biological monitoring efforts, consistent abiotic monitoring and important monitoring sites * Recommended to continue partnerships with stakeholders and increase awareness of monitoring efforts |
| * BlueTriton | * Biological Monitoring Program: BlueTriton Brands Aberfoyle Property * Beacon Environmental Limited and C. Portt and Associates, contracted by BlueTriton to undertake aquatic and terrestrial biomonitoring * A condition instated by the Ministry of Environment, Conservation and Parks, Permit to Take Water for bottling services. * Biomonitoring continues to be a condition of the current Permit to Take Water (PTTW) * PTTW instated as of 2007 | * Annual Monitoring Reports 2018 – 2023. * Before 2018 have not been available for this report but do exist under Nestle Water Canada. * Continuous biomonitoring of aquatic and terrestrial components of the creek * That is, trout and electrofishing monitoring, plant, amphibian, retile, bird and insect species surveys * Invasive species mapping * Ecological Land Classification (ELC) * Reports from 2018 – 2023 can be found at the BlueTriton website under Long Term Monitoring * Groundwater and surface water monitoring initiated in 2000 to characterize the existing hydrogeologic setting and document potential long-term changes to groundwater and surface water. * The monitoring program includes measurement and record-keeping of water-taking, groundwater levels, mini-piezometer levels, surface water levels, surface water flows, surface water temperatures, and measurements of monthly and annual precipitation. |
| * CBM Aggregates | * The following are consultant companies involved in monitoring efforts: * AECOM Canada Ltd. * 8Trees Inc. * Groundwater Science Corp. (GSC) * Limnoterra Ltd. | * AECOM, Groundwater Monitoring Results Report, Lanci Pit, Aberfoyle Ontario 2022 * AECOM, Waste Site Annual Monitoring Report, Aberfoyle 2016 * 8trees Inc., Water Quality Monitoring Report for McMillan Pit, Aberfoyle, Ontario, 2017-2021 and 2023. * GSC 2023 Groundwater monitoring report * Limnoterra Water Quality Report, McMillan Pit Aberfoyle, 2015. |

**Table A1.1.** Surface water quality parameters analyzed once from a July 2013 grab sample from the Side Road 10 bridge crossing.

|  |  |  |  |
| --- | --- | --- | --- |
| **Analyte** | **Collection Date** | **Result** | **Units** |
| Aluminium, unfiltered total | 2013-07-09 | 0.0441 | µg/L |
| Barium, unfiltered total | 2013-07-09 | 68.9 | µg/L |
| Berylium, unfiltered total | 2013-07-09 | -0.0396 | µg/L |
| Bismuth, unfiltered total | 2013-07-09 | -0.668 | µg/L |
| Cadmium, unfiltered total | 2013-07-09 | 2.41 | µg/L |
| Calcium, unfiltered total | 2013-07-09 | 73 | mg/L |
| Carbon, dissolved inorganic | 2013-07-09 | 61.1 | mg/L |
| Carbon, dissolved organic | 2013-07-09 | 10.7 | mg/L |
| Chromium, unfiltered total | 2013-07-09 | 0.165 | µg/L |
| Cobalt, unfiltered total | 2013-07-09 | 0.771 | µg/L |
| Copper, unfiltered total | 2013-07-09 | 1.01 | µg/L |
| Hardness, total | 2013-07-09 | 290 | mg/L |
| Iron, unfiltered total | 2013-07-09 | 72.5 | µg/L |
| Lead, unfiltered total | 2013-07-09 | -1.26 | µg/L |
| Lithium, unfiltered total | 2013-07-09 | 1.98 | µg/L |
| Magnesium, unfiltered total | 2013-07-09 | 26.2 | mg/L |
| Manganese, unfiltered total | 2013-07-09 | 5.01 | µg/L |
| Molybdenum, unfiltered total | 2013-07-09 | 2.13 | µg/L |
| Nickel, unfiltered total | 2013-07-09 | 0.116 | µg/L |
| Potassium, unfiltered total | 2013-07-09 | 1.31 | mg/L |
| Silicates, unfiltered reactive | 2013-07-09 | 4.52 | mg/L |
| Silver, unfiltered total | 2013-07-09 | 1.27 | µg/L |
| Sodium, unfiltered total | 2013-07-09 | 24.9 | mg/L |
| Strontium, unfiltered total | 2013-07-09 | 114 | µg/L |
| Tin, unfiltered total | 2013-07-09 | -6.15 | µg/L |
| Titanium, unfiltered total | 2013-07-09 | -0.214 | µg/L |
| Uranium, unfiltered total | 2013-07-09 | 3.73 | µg/L |
| Vanadium, unfiltered total | 2013-07-09 | 0.116 | µg/L |
| Zinc, unfiltered total | 2013-07-09 | 21.4 | µg/L |
| Zirconium, unfiltered total | 2013-07-09 | -0.102 | µg/L |